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Deliverable D3.1

Simulation Strategy for Convection-permitting Regional Climate Models (CP-RCMs)

Deliverable Title	*Simulation strategy for convection-permitting regional climate models (CP-RCMs)*	
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WP number	3	
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Deliverable D3.1: Document describing the simulation strategy for convection-permitting regional climate models (CP-RCMs).

1. Introduction

The primary goal of WP3 is to produce a portfolio of high impact extreme meteorological events at the pan-European level using CP-RCMs run at horizontal grid spacings of 1.5-3 km. This portfolio will cover both the historical period and the future period up to a temporal horizon of 40 years. The data are then provided to WP4 for an impact analysis, WP2 for generating PDFs of changes in extreme events and to WP5 for use into the seamless projection activities. The data will also be analysed within WP3. Seven models used by 10 modeling groups participate in the completion of CP scale simulations under WP3. The list of groups and corresponding models used is provided in *Table 1*.

Table 1. List of groups and models participating in WP3

GROUP	MODEL	GRID SPACING (km)
CMCC	CCLM	3
CNRM	AROME41t1	2.5
DMI	HCLIM38-AROME	3
SMHI	HCLIM38-AROME	3
KNMI	HCLIM38-AROME	2.5
ETH	CCLM	2.2
GERICS	REMO	3
ICTP	RegCM4	3
IPSL	WRF	3
UKMO	UM	2.2

The simulations planned for WP3 can be divided into two main streams:

1) Model development and validation stream
2) Model projection stream

Within the context of Stream 1), the models are run for an actual observed period using ERA-Interim initial and lateral meteorological boundary conditions, while for Stream 2) the forcing meteorological fields will be provided by general circulation models (GCMs) for historical and future periods. Intermediate resolution RCM simulations will be performed (~12 km) in order to provide boundary conditions for the CP-RCMs. In other words, a double one-way nesting approach is adopted by which the data from ERA-Interim or GCMs are used to drive the intermediate resolution RCMs, whose output in turn drives the CP-RCMs.

A number of discussions took place during the first year of the EUCP project aimed at elucidating the model simulation strategy for both simulation streams so that information at pan-European scale can be provided – alongside that coming from the global models in WP1, 2 and 5. In the original proposal this entailed the completion of two types of simulations at CP resolutions, one based on continuous decadal runs over a common pan Alpine domain, and the other based on a number of individual events. After extended discussions, both face-to-face and telematic, it was decided to change the event-based approach into a continuous decadal simulation approach. This has advantages over the original proposal in that it i) circumvents problems related to the intialization of soil moisture; ii) coordinates, and thus benefits from synergies, with other ongoing modeling activities; and iii) allows more flexibility in the choice of the types of extremes to be considered. This has led to the following improved simulation strategy.

2. Project Objectives

With this deliverable, EUCP has contributed to the achievement of the following objectives (Description of Action, Section 1.1):

Table 2: EUCP Objectives associated with this deliverable

No.	Objective	Yes	No
1	Develop an ensembles climate prediction system based on high-resolution climate models for the European region for the near-term (~1-40 years)	√	
2	Use the climate prediction system to produce consistent, authoritative and actionable climate information		
3	Demonstrate the value of this climate prediction system through high impact extreme weather events in the near past and near future	√	
4	Develop, and publish, methodologies, good practice and guidance for producing and using EUCP's authoritative climate predictions for 1-40 year timescales	√	

3. Domain choice

Figure 1 depicts the domains that will be used in the WP3 CP-RCM simulations.

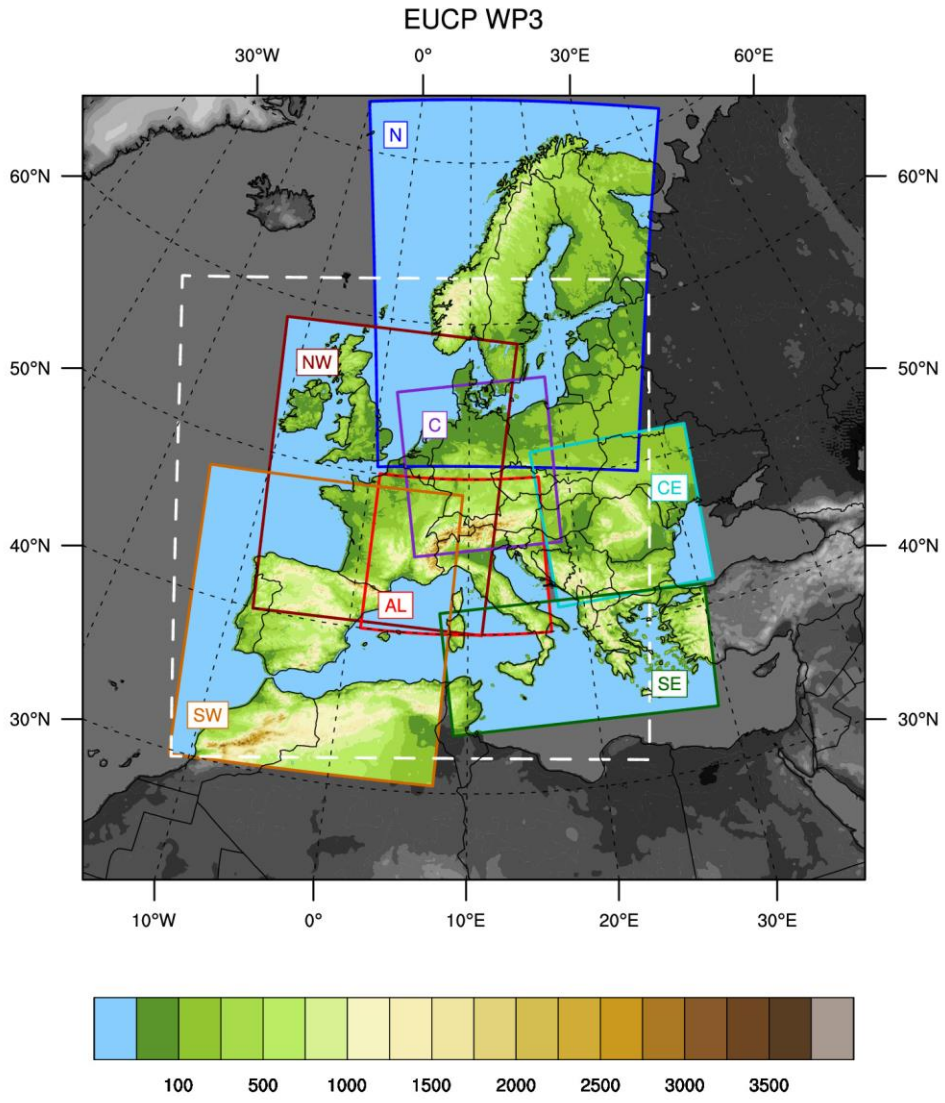

Figure 1: Set of domains used for CP-RCM simulations. The dashed box indicates the European domain used by ETH and UKMO

The set of domains was chosen in order the provide information at the pan-European level whilst allowing continuous running of the models. It includes the common pan-Alpine domain (continuous red line) plus six domains covering most of the European territory: North West (NE), South West (SE), Central (C), North (N), Central East (CE), South East (SE). Since it is unfeasible for all groups to complete simulations over all domains it was decided that all groups will complete simulations over the common pan-Alpine domain (see below), and each group will complete simulations over at least one additional domain, in a way that, for each domain, simulations from at least two groups are available. In this way a minimum assessment of inter-model uncertainty can be carried out for each domain (more complete for the pan-Alpine one). Note that two models, ETH and UKMO, will run an almost full-European domain, so that the information from these runs can be used also for most of the other domains. Also note that ICTP and SMHI will complete simulations for two domains in addition to the pan-Alpine one. *Table 3* summarizes the distribution of groups running over the

different domains, along with the approximate latitudes and longitudes of the corner points identifying the analysis region for each domain.

Table 3: List of groups running CP-RCM experiments over the different domains of Figure 1 and corresponding corner points identifying the analysis region for each domain. Note that UKMO and ETH will run over the large European domain shown in Figure 1

DOMAIN	DOMAIN CORNER POINTS	GROUPS
NW	SW: 40.4 N, -8.0 E SE: 40.4 N, 11.0 E NE: 58.6 N, 15.2 E NW: 58.6 N, -12.5 E	CNRM, KNMI, ETH, UKMO
SW	SW: 30 N, -10 E SE: 33 N, 7.4 E NE: 48.9 N, 5.7 E NW: 45.5 N, -15 E	CMCC, IPSL, ETH, UKMO
SE	SW: 34.3 N, 12.5 E SE: 34.3 N, 28.5 E NE: 40.9 N, 29.4 E NW: 40.9 N, 11.5 E	ICTP, ETH, UKMO
C	SW: 44.5 N, 5.0 E SE: 45.5 N, 18.0 E NE: 56.0 N, 18.0 E NW: 53.0 N, 1.0 E	GERICS, ETH, UKMO
CE	SW : 41.5 N, 17.8 E SE: 41.5 N, 31.3 E NE: 51.6 N, 32.8 E NW: 51.6 N, 16.4 E	SMHI, ICTP, ETH, UKMO
N	SW: 50.7 N, 1 E SE: 49.7 N, 26.7 E NE: 70.6 N, 44.1 E NW: 72.6 N, -9.4 E	DMI/SMHI, GERICS

4. Simulation length and periods

As already mentioned, in the revised simulation protocol, decadal-long continuous experiments will be carried out for all domains, except for one group (KNMI) which will run seasonal long summer simulations over the NW domain. The simulation periods for the continuous runs are as follows, (not including a spin-up period):

Stream 1, ERA-Interim driven : 1/1/2000 - 31/12/2009
Stream 2: GCM-driven, historical period : 1/1/1996- 31/12/2005
Stream 2: GCM-driven, future period : 1/1/2041-31/12/2050

An optional third for future climate period, 1/1/2090 - 31/12/2099, can be simulated by groups based on the availability of sufficient computational and personel resources. The scenario used for the future time slice simulations is RCP8.5 in order to maximize the signal to noise ratio.

5. GCM-RCM Matrix

In principle, a full exploration of uncertainties in future projections would require the completion of a large GCM-RCM matrix, whereby each RCM is driven by multiple GCMs, possibly for multiple scenarios. In practice, whilst the EUCP set up is state-of-the-art, running the full matrix is still not feasible under the WP3 protocol due to the computational requirements to run CP-RCMs. For WP3, only one historical and one future climate decade driven by one GCM can be simulated with each CP-RCM, leading to a sparse matrix. If the matrix, however, includes GCMs with varying climate sensitivities, a rough assessment of uncertainties can be carried out, possibly in conjunction with the use of techniques such as pattern scaling.

The initial GCM-RCM simulation matrix will be based mostly on CMIP5 GCM simulations, and it is shown in *Table 4*. Note that, this matrix includes GCMs with high (HadGEM), medium (MPI) and low (EC-EARTH) global climate sensitivites, so that a portion of the full CMIP5 sensitivity range is considered. The matrix can be eventually augmented or updated, if feasible, with CMIP6-driven simulations if these become available within the time frame of the EUCP project. The GCM-RCM matrix of Table 3 should thus be considered as a preliminary one, with the possibility of being updated and improved/extended during the progress of EUCP. An important element of EUCP will be the evaluation the fraction of the inter-GCM uncertainty spanned by this matrix over the different European sub-domains.

Table 4: Matrix of GCM-RCM experiments currently planned for WP3 simulations. The last column indicates whether the intermediate resolution simulation is part of the EURO-CORDEX ensemble

GROUP	GCM	CMIPx	RCM (intermediate)	CORDEX
CMCC	EC-Earth	CMIP5	CCLM	Yes
CNRM	CNRM-CM5	CMIP5	ALADIN63	Yes
DMI	EC-Earth	CMIP5	HCLIM38-ALADIN	No
SMHI	EC-Earth	CMIP5	HCLIM38-ALADIN	No
KNMI	EC-Earth	No	RACMO	No
ETH	MPI-ESM-LR	CMIP5	CCLM	No
GERICS	MPI-ESM-LR	CMIP5	REMO	Yes
ICTP	HadGEM	CMIP5	RegCM4	No
IPSL	IPSL-CM5 or 6	CMIP5 or 6	WRF	Yes
UKMO	HadGEM3-GC3.1-N512	AMIP	No	No

6. Additional experiments aimed at process studies

Consideration will be given to additional approaches aimed at elucidating processes that might affect the characteristics of extreme events, such as the "Pseudo Global Warming" by which boundary conditions from the ERA-Interim simulations are perturbed using either idealized perturbations or change fields from GCM projections.

7. Conclusions

As first task of WP3, a simulation strategy was devised for the CP-RCM experiments planned in WP3 in order to meet its goals of providing a portfolio of extreme meteorological events at the pan-European level for the present period and the future up to a time horizon of ~40 years from present. The strategy is described in this document, and it has been improved compared to the original proposal by the plan to complete continuous decadal simulations over all domains instead of event-based ones. This strategy will allow us not only to provide a wide range of data for applicaiton to WP2,4,5 but also to address scientific questions such as: are CP-RCMs appropriate tools to study extreme events in a climate change context? What is their added value compared to coarser resolution hydrostatic RCMs? How may global warming affect the characteristics of extreme events over Europe over a time horizon of 1-40 years? How can robust signals and uncertainties be best estimated from a limited number of CP-RCM experiments? Concerning, specifically, the GCM-RCM matrix presented here, although this is the plan at the current time, it is possible that some driving GCMs might be substituted by CMIP6 ones, if these become available and are analyzed during the EUCP project with sufficient lead time to complete the CP-RCM runs. The ERA-Interim simulations are currently under way and are expected to be finished and analysed by the end of April 2019 (Deliverable 3.2). The GCM-driven simulations are expected to begin in the second half of 2019.